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HEMIOPIA AND DECUSSATION IN THE OPTIC CHIASM.

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THE theory of the semi-decussation of the fibres of the optic nerves in the chiasm, is often spoken of as Wollaston's Theory. Wollaston is generally supposed to have been the first to suggest it, in 1824, to facilitate the explanation of a transient hemiopia occurring in his own case; but it is known that Sir Isaac Newton advocated the possibility of a semi-decussation in 1704. The name of Müller is also associated with this theory, and it has been adopted, without question, in nearly all the standard text-books on anatomy, physiology, and ophthalmic surgery.

Within a few years, this long rest has been broken by the defection of a number of pathologists and physiologists, who have advocated the theory of total decussation, maintaining that all the fibres of each optic tract pass across to the eye of the opposite side. The weight of authority and the best of the argument are still on the side of the older theory, and Knapp (*Archives of Ophthalmology and Otology*, vol. i. No. 2, p. 242,) in speaking of the experiments of Morgagni, Gudden, and Admük, says, "The results of

these experiments are: in the dog and cat, if one eye or optic nerve is destroyed, the atrophy strikes both optic tracts, but in the rabbit it strikes only the optic tract of the other side. The present phase of the question of the decussation is the following: In animals that have no common field of vision, the crossing is total; in others that have a common field, the crossing is partial, corresponding to the extent of the common field. In man, there is half crossing." As, however, the subject is still much discussed, it may be considered, to a certain extent, an open one; particularly when we find in so recent a publication as Mr. Carter's *Ophthalmic Surgery* the statement that "It was recently believed that the decussation was only partial, and that the external fibres of each tract went to the same side; but this view is not supported by the later investigations."

In fish, the arrangement is simple and plain enough; the right nerve crosses entire above the left, and, if it may be considered as demonstrated by physiological experiments that in animals of higher development, and with a common field of vision, there is a partial decussation, the manner in which this twisting of the fibres has been brought about furnishes a curious problem for evolutionists. As has been pointed out by Wollaston, however, though the anatomical analogy has not been maintained, the physiological analogy is still complete; for as, in the case of animals that have not a common field of vision, the axes of the eyes are directed outwards instead of forwards, the visual impression of objects on either side is conveyed to the opposite hemisphere of the brain, just as the

semi-decussation theory supposes it to be in animals with a common field.

There seem to be difficulties in the way of the microscopical study of the chiasm in man that prevent an agreement of authorities. Gudden insists that semi-decussation can be determined by a series of careful sections of the chiasm, while Mandlestamm and Michel claim that their anatomical researches demonstrate that the crossing is complete. This refers the question to clinical observation and pathological investigation, and may give an interest to the report of cases that bear upon it

The terms right and left hemiopia, as they are now universally used, are rather unfortunate, and may lead to confusion in the minds of students, while even those more familiar with the subject may often have to hesitate for a moment to translate them from their real to their accepted meaning. This confusion of terms becomes more marked when we remember that the terms hemeralopia and nyctalopia are used in a different sense. By hemeralopia we express the fact that the patient can see in daytime but cannot see at night, that he is night-blind; while by right hemiopia, on the contrary, we mean that the patient cannot see on the right side but can see on the left. Naturally, therefore, the expression "so-called" right or left hemiopia is sometimes met with. These terms can be made correct only by applying them to the retina instead of to the field of vision, for in right hemiopia the right side of the retina remains unaffected, and enables the patient to see to the left. By right hemiopia, therefore, we really mean right half-blindness.

The only entirely appropriate cases for the illustra-

tion of theories of decussation are those in which there is a sharp line of demarcation, symmetrical on the two sides, between the deficient and the unaffected portions of the visual field, and in which there is no suspicion that the symptom may be due to disease of the retina or disk, or of the optic nerve in front of the chiasm. For example, a patient recently presented himself at Wills Hospital with well-marked binocular hemiopia which at once suggested intracranial disease, but the ophthalmoscope showed an almost symmetrical retinal separation in each eye. This, of course, was a mere chance, but a chance not less likely to occur in the disk or in the anterior part of the nerve. Even in the chiasm, it seems hardly possible that any form of disease or of pressure from neighboring growths should accurately dissect out a certain set of fibres, leaving the others completely intact; so that a sharply defined, symmetrical, binocular hemiopia may be considered as furnishing a very strong presumption, at least, in favor of lesion of the optic tract or of the brain behind it.

The following two cases are fair illustrations of cerebral hemiopia.

J. H., sight good until four weeks before examination, when it became obscured suddenly. Had had diabetes three or four years ago, but sugar had disappeared entirely from urine, and health seemed restored. Had lately had some headache, feeling of weight on top of head, and slight mental confusion and loss of memory; the right side of the field of vision was deficient, almost obliterated to the median line in each eye. In the left side he could read ordinary print with a slowness and difficulty that seemed to be due partly to imperfect vision, and partly to loss of memory and of the power of mental concentration. There was no other paraly-

sis. The ophthalmoscopic appearances were normal, except a slight engorgement of the retinal veins and several small yellowish-white spots in the neighborhood of each macula, suggesting albuminuria; albumen was found in the urine in considerable quantities. Eight months afterwards, the edge of the obscure portion of the field had receded, and was three inches to the right of the point of fixation, at a distance of one foot from the eye. The line of demarcation was still sharp and vertical; and perfectly symmetrical in the two eyes, so that the same diagram accurately described the field in each.

The ophthalmoscopic appearances in this case were barely sufficient to excite a suspicion of the earlier stages of albuminuric retinitis, which, as yet, interfered but little with vision. The right hemiopia pointed to a lesion of the left hemisphere of the brain, while the albuminuria indicated a condition of the vessels that would predispose to hemorrhagic extravasation, and the mental symptoms confirmed the diagnosis of cerebral disease.

The second case has more interest, from the fact that it was complicated with other symptoms which located the disease almost positively on one side of the brain.

G. H., æt. 29, six months before his admission to Wills Hospital had chancre, followed by eruption on the face, sore throat, and other unmistakable, secondary, syphilitic symptoms. About four months after the appearance of the chancre he had violent headache, which continued in less degree; but, three days before admission, he read for several hours with ease, before going to bed. The next morning he awoke with dizziness and dimness of sight. Double vision was first noticed two days afterwards. The following condition was found on examination. On the right side

there were partial ptosis, complete paralysis of internal rectus, paresis of superior and inferior recti, and sluggishness of the pupil. There was complete left hemiopia on both sides, with fair vision in the right halves of both fields. No other symptom in the left eye but diminution of vision. O. D. V. = $\frac{20}{6}$? O. S. V. = $\frac{20}{L}$. The ophthalmoscope showed only engorgement of the retinal veins, more marked in the right eye. On rough examination, there seemed to be a perfectly vertical and symmetrical line of demarcation through the macula; but when the fields were carefully taken, this line was found to incline a little from left to right for each eye, more decidedly for the left, and to be a little to the left of the macula on each side. After several weeks of treatment by mercurial inunction and large doses of iodide of potassium, the vision was much improved—O. D. and O. S. V. = $\frac{20}{XXX}$, but there was no change in the hemiopia. A gummy tumor or other lesion might easily involve both the optic tract and the third nerve in their passage over the crus cerebri, or the filaments of both at their origin, without implicating any other nerve; but it is difficult to conceive how disease situated elsewhere than in the right side of the brain could produce this combination of symptoms.

Medical literature furnishes numerous instances of hemiplegia with paralysis of the half of each retina on the side opposite to that of the limbs, and Dr. Hughlings Jackson considers it an almost invariable rule that when bilateral hemiopia is found in connection with hemiplegia, the patient cannot see to the paralyzed side.

It must be admitted, however, that, with a fair amount of ingenuity and a sufficiently strong bias, most of the phenomena of hemiopia can, on merely theoretical grounds, be explained by either theory of decussation. Thus, on the total decussation theory, right-sided hemiopia may be referred to pressure on

the left external angle of the commissure involving the outer half of the left optic nerve and, at the same time, the outer half of the left optic tract, and, consequently, the inner half of the right optic nerve-fibres.

Bitemporal hemiopia may be accounted for by pressure upon the anterior angle of the commissure, involving the inner halves of the optic nerves, and nasal hemiopia by pressure at the posterior angle involving the inner halves of the optic tracts, and, therefore, the outer halves of the optic nerve-fibres.

On the semi-decussation theory, right- or left-sided hemiopia may be rationally explained by supposing a lesion of the optic tract of the opposite side, and binocular, temporal hemiopia may be referred either to pressure in front of the commissure involving the inner halves of the optic nerves, or, behind the commissure, involving the inner halves of the optic tracts. Binocular, nasal hemiopia, cannot be explained by any single lesion, and this has been considered the weak point of the semi-decussation theory. The cases of this form of hemiopia are, however, so few, that, to say the least, they may be considered exceptional, and the existence of double lesions, nearly symmetrical, is almost within the range of possibility. Schoen, writing in 1874, says, "Nasal hemiopia is excessively rare, if ever met with. There is no record of an entirely incontestable case." (*Annales d'Oculistique*, t. lxxii., p. 182.) I have not been able to find a detailed account of any case quite free from complications.

Some cases have been reported in which the lower half of both fields was absent, but I know of nothing

to disprove Mauthner's assertion that no well-described case with a sharply defined horizontal line is on record. Such a case might be explained, with about equal plausibility, on either theory.

Though the theoretical discussions, which have been considerably extended on this subject, are often extremely ingenious and always interesting, any decision reached through them is, after all, merely an opinion, and no observations are positively conclusive that are not confirmed by post-mortem examination. I believe that wherever post-mortem evidence is entirely unequivocal, it will be found on the side of semi-decussation.

When we remember the special prominence of *nasal hemiopia* in the discussion of this question, there seems a remarkable absence of this positive kind of evidence connected with it. The literature of hemiopia furnishes only four cases of this form of the affection, in which post-mortem examinations have been made. Though, with perhaps one exception, none of these cases are free from local complications of disease of the retina, or of the nerve near the ball, or of both, which, on a rigid sifting, might fairly rule them out, a brief account of them may have, at least, some historical interest.

The only one in which the ophthalmoscopic appearances are reported as normal, is recorded by Müller (quoted by Knapp, in Brown-Séquard's Archives). The symptoms were complicated, and it was as much a case of temporal as of nasal hemiopia. There was first temporal, binocular hemiopia, then total blindness, and then nasal hemiopia with well-defined lines. Post-mortem examination showed a tumor in the sella turcica as large as a medium-sized apple.

A second case is given by Schüle (quoted by Plenck, in *Archives of Ophthalmology and Otology*, vol. v. No. 2, p. 201). "The disease began with amblyopia in the right eye, atrophy of the papilla, with blue discoloration and marked reduction of eccentric vision; later, atrophy commenced in the left papilla, with a similar course and changes in the arterial vessels. Autopsy: the ventricles much dilated; the infundibulum and both nerves distinctly atrophied and of a grayish color." The same author also quotes a case observed by Wegner and Schmidt. The perceptive and non-perceptive portions of the visual fields were not divided by a sharply defined line. The ophthalmoscope showed neuro-retinitis. On post-mortem examination, a tumor was found in the median line of the brain, involving the infundibulum, fornix, and septum pellucidum. The microscope showed decided atrophic changes both in the nerves and retinae. The fourth case is reported by Knapp, in *Brown-Séquard's Archives*. Vision was very much diminished throughout the whole field, the lines between the totally and the partially obscured portions were not quite symmetrical in the two eyes, and there was optic neuritis in both. On post-mortem examination, the brain was found healthy, but the arteries at its base atheromatous. The nasal hemiopia was referred by Dr. Knapp to paralysis of the outer half of each retina, resulting from compression of the external fibres of both the nerve and optic tract, on both sides, by the anterior cerebral and posterior communicating arteries. It must be admitted that this ingenious arrangement has not seemed quite so clear to the opponents of semi-decussation.

Binocular, temporal hemiopia, in which the inner halves of the retinae are involved, is also a very rare affection; and beside that of Müller, mentioned above, in which temporal hemiopia preceded the nasal, I can learn of only one post-mortem examination in such a case. It is reported by Sämisch (Plenck, loc. cit.). In both of these cases there were sarcomatous

growths involving the anterior angle of the commissure, and the hemiopia, therefore, admits of equally satisfactory explanation on either theory.

Autopsies in cases of homonymous *bilateral hemiopia* have been more numerous, and their results more definite. It is worthy of note that in all the reported cases the lesion has been behind the chiasm, and therefore more strictly cerebral; these cases are in the nature of positive evidence, and, to my mind, are quite conclusive in favor of the semi-decussation theory.

The first case of hemiopia on record is reported by Wollaston, who was himself the subject of it. After his death, an examination of the brain revealed a lesion of the right optic thalamus, which is described as converted into a tumor as large as a hen's egg, harder than the brain, and somewhat of a caseous substance. (Mackenzie on the Eye, p. 931.) The connection of this tumor with the hemiopia, however, is far from clear, as the symptom, which occurred twice with an interval of twenty years, lasted only fifteen or twenty minutes each time, and the right halves of the retinae were involved on the first occasion and the left halves on the second.

It seems more likely that this was one of those singular cases of transitory hemiopia, not very uncommon, due to some temporary cause, and not dependent on discoverable organic change.

The following post-mortem records, which are all that I have been able to find, are of quite recent date.

Two are reported in the Archives of Ophthalmology and Otolaryngology, vol. v. No. 2, one by J. Hirschberg, of Berlin, and one by Dr. T. R. Pooley, of New York. In the first, there

was "defined, symmetrical, right-sided defect in the visual field of both eyes, with a nearly normal acuity of vision and a normal ophthalmoscopic picture, accompanied by aphasia and hemiplegia of the right side. The autopsy revealed a tumor as large as an apple in the left frontal lobe, implicating the left optic tract." In Dr. Pooley's case, there were right-sided hemiopia, sharply defined in the vertical meridian, partial hemiplegia of right side, and choked disk in the left eye, but no change of appearance in the right. On post-mortem examination, a gummy tumor was found in the left posterior lobe of the brain. The left thalamus opticus and the neighboring brain-substance were completely softened. A third case is also referred to in the same journal (Jackson, quoted by Plenk). There was bilateral, left hemiopia, and the autopsy showed pronounced softening of the right optic thalamus.

In a case of left hemiplegia, left hemi-anæsthesia, and left hemiopia, Dr. Hughlings Jackson diagnosed disease of the right optic thalamus, and post-mortem examination showed softening confined to the posterior and inner part of the right optic thalamus. (*Medical Times and Gazette*, Oct. 28, 1876.)

Dr. Gowers also reports a case in which there had been hemiopia for several months before death, and in which post-mortem examination showed softening of the posterior tubercle of the optic thalamus on the opposite side. (*Ibid.*)

We may add to these, as approaching very nearly to an autopsy in the accuracy with which the lesion may be located, the case of gunshot injury of the head reported by Drs. Keen and Thomson (*Photographic Review of Medicine and Surgery*, Feb. 1871). The wound of entrance was in the middle line, one and a quarter inches above the external occipital protuberance, and the wound of exit two inches to the left of the median line, and three inches above the wound

of entrance. The patient was unconscious for several months, and had right hemiplegia for about a year. More than eight years after the injury, the field of vision was "found to be divided for each eye by a line passing through its centre, in the vertical direction: total blindness existing to the right, and perfect vision to the left, of this line." These cases need little comment; they are typical, uncomplicated instances of cerebral hemiopia, and their evidence is strong in favor of semi-decussation.

There is another form of hemiopia which it may be of interest to mention in this connection, though not enough is known of it to give it any real scientific weight in the discussion. I refer to those strange cases of transient hemiopia which are met with most frequently in subjects of migraine, in whom they seem to be a kind of prodrome of the headache, though they occasionally occur without any other symptom. We not only know nothing of their etiology, but even the symptomatology, derived of necessity from the accounts of patients, is not definite or accurate. Usually, merely the fact that only the halves of objects are seen is reported, and we are without the means of knowing whether, in frequently recurring cases, the same side of the retina is always affected. In Wollaston's case, opposite sides were affected in the two attacks, but the interval between them was so long that they can scarcely be considered as phenomena of the same disease. He relates the case of one of his friends, who had been habitually subject to this symptom for sixteen or seventeen years whenever his stomach was deranged, in whom the blindness was invariably in the right side. A medical gentleman who recently told me of his own

case, assured me that the blindness was always on the same side, and that the line of demarcation was vertical and sharply defined. The symptom occurred quite frequently during his student-days, and was always the forerunner of a raging headache.

Wecker (*Maladies des Yeux*, p. 384) speaks of recurrences of transient, bitemporal hemiopia, with sharp lines of demarcation, unaccompanied by cerebral symptoms, and explains them by supposing an insufficient flow of blood, something like what is thought to occur in epilepsy, in certain regions of the brain supplied by symmetrical arteries. This is an attractive theory, and would be satisfactory if it could be shown that such symmetrical regions of the brain only were always involved. A lady who comes occasionally to my office, has been subject, for several years, to attacks of *inferior hemiopia* coming on suddenly every four or five months, preceded by no warning, and followed by no other symptom. She is in good health, and is not of an hysterical or nervous temperament. The attack lasts fifteen or twenty minutes, during which the field of vision is bounded by a sharp, perfectly horizontal line, and all below this is in the blackness of darkness. She has sometimes been seized on the street, and, being unable to see her feet or the ground for some distance in front of them, has been greatly embarrassed to find her way home. I believe that this case, which gives no aid or comfort to either theory of decussation, is unique, and that, in the present state of medical science, it does not admit of intelligent explanation.

Doubtless there are still many more things in the anatomy and physiology of the brain than are dreamt of in our philosophy, and it must be admitted that

cerebral pathology is not, as yet, a good field for complacent dogmatism; since so many cases are on record in which the most definite and unmistakable post-mortem revelations have been preceded by symptoms of the wrong kind, or on the wrong side, or in which the entire absence of symptoms has bid defiance to all theories: but perhaps few of these theories rest on a firmer basis of physiological experiment, clinical observation; and post-mortem evidence, than that of the semi-decussation of the nerve-fibres in the optic chiasm.

Supposing the theory of semi-decussation to be correct, an interesting point in the minute anatomy of the retina, that must depend upon the study of hemiopia for its elucidation, is the distribution of the nervous filaments at the dividing line between the two halves of the retina. The observations upon the exact position of the line of demarcation in hemiopia have been too few, and not sufficiently in accord with each other, to be much more than suggestive: as illustrated by the first case reported above, this line may even vary very considerably at different stages of the disease, while still continuing perfectly symmetrical in the two eyes. It is a significant fact, though, that whenever observers have not contented themselves with stating that half the field of vision has been obliterated, but have been careful to define the limits of the obscured portion with accuracy, it is found that this portion has been a little less than half. This, as far as it goes, supports the theory of Hirschberg, that there is a retinal zone, of about six degrees, which would be halved by a vertical line drawn through the point of fixation, supplied in common from both optic tracts.



